

Pacific University

CommonKnowledge

College of Optometry

Theses, Dissertations and Capstone Projects

1993

Enhancement of visual reaction and response times in elders

Timothy Dieter
Pacific University

Paul Perron
Pacific University

Recommended Citation

Dieter, Timothy and Perron, Paul, "Enhancement of visual reaction and response times in elders" (1993).
College of Optometry. 1050.
<https://commons.pacificu.edu/opt/1050>

This Thesis is brought to you for free and open access by the Theses, Dissertations and Capstone Projects at CommonKnowledge. It has been accepted for inclusion in College of Optometry by an authorized administrator of CommonKnowledge. For more information, please contact CommonKnowledge@pacificu.edu.

Enhancement of visual reaction and response times in elders

Abstract

Visual reaction and response times have been shown to increase with age. Research on driving has shown that quick reaction times are important for safe driving. To determine if visual reaction and response times can be enhanced among elders (mean age= 63.2), this study tested a method of training that has previously shown to improve reaction and response times among a group of young adults. Although the elders who completed the training program showed improved motor response times, we cannot determine if the change was due to the training program or due to a learning effect due to task familiarity associated with repeated testing of the dependent variables. We believe this area of research warrants further investigation.

Degree Type

Thesis

Degree Name

Master of Science in Vision Science

Committee Chair

Bradley Coffey

Subject Categories

Optometry

Copyright and terms of use

If you have downloaded this document directly from the web or from CommonKnowledge, see the "Rights" section on the previous page for the terms of use.

If you have received this document through an interlibrary loan/document delivery service, the following terms of use apply:

Copyright in this work is held by the author(s). You may download or print any portion of this document for personal use only, or for any use that is allowed by fair use (Title 17, §107 U.S.C.). Except for personal or fair use, you or your borrowing library may not reproduce, remix, republish, post, transmit, or distribute this document, or any portion thereof, without the permission of the copyright owner. [Note: If this document is licensed under a Creative Commons license (see "Rights" on the previous page) which allows broader usage rights, your use is governed by the terms of that license.]

Inquiries regarding further use of these materials should be addressed to: CommonKnowledge Rights, Pacific University Library, 2043 College Way, Forest Grove, OR 97116, (503) 352-7209. Email inquiries may be directed to: copyright@pacificu.edu

**ENHANCEMENT OF VISUAL REACTION AND RESPONSE
TIMES IN ELDERS**

BY

Timothy Dieter

&

Paul Perron

A Thesis Submitted to the Faculty of the
College of Optometry
Pacific University
Forest Grove OR

Advisor:

Bradley Coffey O.D.

Signatures:

Authors: Timothy Dieter

Timothy Dieter

Paul Perron

Paul Perron

Advisor: Bradley Coffey

Bradley Coffey O.D.

BIOGRAPHIES OF THE AUTHORS

Paul Perron was born in Laffayette, Louisiana, completed high school in Casaroble, California, and graduated from University of California, Davis with a Bachelor of Science degree in Physiology in 1983. Upon completion of his Doctor of Optometry degree from Pacific University College of Optometry in May of 1993, he plans to practice full scope optometry, with an emphasis in vision therapy, in northern California.

Timothy Dieter was born in Crookston, Minnesota, completed high school in Sebeka, Minnesota, and graduated from North Dakota State University in Fargo, North Dakota, with a Bachelor of University Studies in 1989. Upon completion of his Doctor of Optometry degree from Pacific University College of Optometry in May of 1993, he plans to practice full scope, behavioral optometry in private or group practice setting.

ACKNOWLEDGMENTS

The authors would like to thank Pacific University College of Optometry for facilitating our research project. We would also like to thank Monte Beerbower for his assistance in subject training and everyone else who may have helped our project in anyway.

A very special thank you goes to Dr. Coffey for his guidance, input, knowledge of research, statistics, and especially for his patience and perseverance. He made our project an enjoyable learning experience.

CONTENTS

ABSTRACT	1
INTRODUCTION	2
METHODS	
Subjects	5
Instruments	5
Procedure	6
RESULTS	11
DISCUSSION	14
REFERENCES	16
FIGURES AND GRAPHS	18

ABSTRACT

Visual reaction and response times have been shown to increase with age. Research on driving has shown that quick reaction times are important for safe driving. To determine if visual reaction and response times can be enhanced among elders (mean age = 63.2), this study tested a method of training that has previously shown to improve reaction and response times among a group of young adults. Although the elders who completed the training program showed improved motor response times, we cannot determine if the change was due to the training program or due to a learning effect due to task familiarity associated with repeated testing of the dependent variables. We believe this area of research warrants further investigation.

INTRODUCTION

It is commonly known that people are living longer and healthier lives today than in past generations. This fact and the large group of aging post-war baby-boomers will create an expanding elder population in the years to come. The optometric profession must be ready to offer services that will provide the quality of life expected by this age group.

One aspect of quality of life that elders enjoy is ease of mobility. The automobile has become an integral part of American life, allowing us to move from one activity to another with minor effort and few constraints. As people age, driving may become more difficult and even hazardous. Although elder drivers do not increase the overall number of traffic accidents or violations significantly (Evans, 1988), their rate of traffic accidents and citations per mile is higher than any other age group except the youngest drivers (Husten and Janke, 1986; Planek, 1973). Compared to younger drivers, elder drivers are also involved in more two-vehicle accidents than single-vehicle accidents (Campbell, 1966).

An efficient and acute visual system is needed for safe driving. Burg (1967, 1968) and Hills and Burg (1977) found a low but systematic correlation between accident experience, binocular distance acuity and dynamic visual acuity in a study of 17,500 California drivers, 55 years of age or older. Henderson and Burg (1974) assigned weights to the visual functions thought to be important to driving. In ascending order of importance they were: detection of angular motion, detection of motion in depth, size of useful visual field, acuity, saccadic fixation and dynamic acuity.

All states have visual acuity requirements that must be met prior to receiving a driving license. But according to Henderson and Burg's (1974) list, this requirement is only one of several visual functions important for driving. Assuming each state tests an applicant's acuity prior to issuing a driving license, this factor in driving safety should, theoretically, not be a problem. Two other visual functions listed, detection of angular motion and detection of motion in depth, are usually precursors to a visual-motor action during driving. Such action is dependent upon the person's ability to receive the visual stimulus, process the information, and react in an appropriate manner.

This processing and reaction to the visual stimulus takes time. The longer it takes, the more hazardous driving could be. A study by Brown (1991) showed that reaction and response times to a visual stimulus increase steadily as a function of increasing age in people over the age of 50 (Figure 1). Can a vision enhancement program that addresses this change in reaction and response times improve a person's driving abilities and possibly influence the driving necessities of rapid detection of angular motion, detection of motion in depth, and dynamic acuity?

***** Insert Fig. 1 About Here *****

Blades and Young (1986) performed a study designed to investigate whether visual reaction and response time could be improved with training. Young adults underwent a 15 session training regimen on the Eyespan Eye-Hand Coordinator (Figure 2). The participants' reaction and response times to a visual stimulus were measured using the Reaction Plus instrument (Figure 3) prior to and after the training program. Subjects in both the experimental and control groups showed a significant decrease in reaction and response times associated with the training. Table 1 shows the difference between post-training and pre-training reaction, motor response, and total response times. The control group change is significantly less than the experimental group in all three categories. The control group improvement is considered a "practice effect" due to repeated testing with the Reaction Plus device. With the practice effect factored out of the experimental group, the change in total response time is nearly 15%. Velenovsky and Prasad (1987) performed a similar study with similar results, suggesting that reaction and response speeds are trainable.

***** Insert Fig. 2, Fig. 3 and Table 1 About Here *****

A study by Van Fraechem and Van Fraechem (1977) reported improvement in reaction times in previously sedentary elder females after a short training period. Other research indicated that rotary pursuit performance and Purdue pegboard scores were improved after a two month training program utilizing an arcade-style videogame in 13 subjects, 61-78 years old

(Drew and Waters, 1986). Based on the results of these studies we administered a training program similar to the Blades and Young program in order to assess the trainability of visual reaction and response times in people over the age of fifty.

METHODS

Subjects:

14 female and 5 male subjects from the ages of 50 to 80, with a mean age of 63.2 years, completed the study. The majority of subjects participated in the Brown study, which established norms for visual reaction and motor response times in elders and were recruited by telephone and mail. The remainder came to us by word of mouth and by information flyers posted around the town of Forest Grove.

All subjects were in good general health, with no major physical impairments to movement such as arthritis, bursitis or rheumatism, etc. Habitual visual acuities were 20/40 or better, OD, OS and OU. Confrontation visual fields were normal and no strabismus was present with unilateral cover test. Any major field defects or strabismus would make the subject ineligible. Subjects could not be taking any central nervous system depressants or stimulants two weeks prior to, or during training. All the screening criteria were assessed prior to the first day of testing/training. Preferred eye, hand and foot were determined prior to the onset of training for qualified subjects.

As a reward for participation, subjects were given a certificate for a free visual exam at any Pacific University Family Vision Center. As an additional incentive, 3 free dinners for 2 were offered to subjects. Two dinners were offered for the top improvements in eye-hand coordination and the remaining dinner was offered by random drawing amongst the rest of the subjects. The subjects were told of the free dinners after the initial test data were taken and before the training began. Eligibility for the free exam and free dinners was contingent upon completion of the training.

Instruments:

Dependent measures were recorded on the Reaction Plus instrument. The Reaction Plus device (available from W.R. Medical Electronics, Stillwater, Minn.) allows specific determination of reaction time (Rx), motor response time (MR) and total response time (Rp). The control console, (Figure 4) has a silent trial-initiating switch, reset button and two 1/100 second chronometers. One chronometer records Rx, the other Rp. MR is calculated by subtracting Rx from Rp. The subject's eye-hand timing console, (Figure 3) has a ready button, alignment marks and

stimulus light. The eye-foot apparatus, (Figure 5) uses the ready button and stimulus light of the subject's console for testing; eye-foot measures are taken using a dual pedal apparatus. Definitions of Rx, MR and Rp are as follows:

Rx = The time elapsed from onset of the stimulus light coming on until the subject releases the ready button.

Rp = The time elapsed from onset of the stimulus light coming on until the subject depresses the stimulus light.

MR = $R_p - R_x$; the amount of time required to make the motor movement of the hand or foot.

***** Insert Fig. 3, Fig. 4 and Fig. 5 About Here *****

The subjects were trained on the Monarch America Eyespan instrument (Figure 2). This 122 cm square, wall mounted instrument is comprised of 64 stimulus lights which also function as response buttons. In mode A, the stimulus light stays lit until depressed. Once depressed, another random light appears on the display. This sequence continues for a preselected time period, after which the instrument displays the number of correct responses. In mode B, the stimulus light stays lit only for a preselected time period and moves on to the next random light regardless of a correct response. This mode continues for a preselected time period, at which time the total number of correct responses is displayed.

Procedure:

The Rx/Rp measurements were conducted in accordance with the testing protocol of the Pacific Sports Visual Performance Profile (Coffey and Reichow, 1990). After a subject qualified for the study by successfully completing the screening tests he/she was scheduled for pre-training Rx and Rp measures, and for the first training visit. With the Reaction Plus instrument, each subject was given a demonstration of the testing procedure prior to each test session for both the eye-hand and eye-foot Rx and Rp measures. The subjects were given 4 practice trials per each hand and foot on the first day of testing and 2 practice trials for each testing session thereafter. There were a total of 4 test sessions: prior to training sessions 1, 6, 11, and after 15

training sessions. Each testing session was comprised of a total of 40 scored trials; 10 for each hand, 10 for each foot.

The following instructions were given to the subjects for all test sessions of Rx and Rp on the Reaction Plus:

1. This instrument is used to measure visual reaction time.
2. Place the palm of your right/left hand on this button so that your hand lays up adjacent to the line.
3. The ready light will come on when you have placed your hand on the reaction button.
4. Position yourself with your head directly over the response button.
5. I will say "ready".....and within 1 to 5 seconds the response button will light up.
6. Move your hand over and depress the button as quickly as possible (Tester demonstrates).

The same instructions for the eye-foot testing were used except that the foot was used in place of the hand. Also, the position of the subject was sitting upright instead of standing, with head directly over the response button.

For both the eye-hand and eye-foot measurements, after the experimenter said "ready" the foreperiod time was varied between 2 and 4 seconds and done in such a way that the subjects were unaware of the length of the foreperiod. The experimenter stood behind the subject to keep the control console out of sight of the subject.

For eye-hand testing the Reaction Plus was placed on a table with the top of the device 86 cm above the floor. The subject was instructed to stand comfortably in front of the instrument.

For the eye-foot tests, the Reaction Plus was placed on edge, facing subject, 88 cm from center of response button to floor. There was a 2.5 meter lateral separation between the Reaction Plus and the front edge of standard, hard surface library chair. The foot-pedal system lies 36 cm in front of the chair and the seat top 46 cm above floor. The chair and foot-pedal system was anchored to the floor with tape.

Subjects were scheduled to visit the clinic once each business day for a 3-week period to perform the training task.

The following instructions were given to the subjects for training on the Eyespan:

Mode A:

1. While standing relaxed, fully extend your arms so that your fingertips comfortably touch the Eyespan directly in front of you.
2. I will cue you by saying "ready, begin" as I push the start button.
3. When you see one of the lights turn on, depress it as quickly as you can.
4. Another light will come on automatically and, again, turn it off as quickly as you can.
5. Your task is to turn off as many lights as you can in one minute.

Mode B:

1. Now we will do the same thing again, but this time to score you must press the lighted button before it goes out. The buttons will remain lit only briefly, so you must go quickly in order to score.

No instruction for fixation or which hand to use was given. Each subject was asked if he/she had any questions, to insure understanding of the task. The Eyespan's vertical orientation was adjusted so the fixation line was eye level with the subject. The illumination level was held constant at 7 footcandles for all testing and training procedures.

The subjects participated in 15 training sessions over a period of 3 to 4 weeks. The training and testing schedule included:

First meeting:

Entrance criteria measured and determination of eligibility.

Training day 1:	Rx, Rp eye-hand, eye-foot testing; 4 mode "A" and 4 mode "B" Eyespan trials. Total time about 30 minutes.
Training days 2-5:	4 mode "A" and 4 mode "B" Eyespan trials.
Training days 6-10:	4 mode "A" and 4 mode "B" Eyespan trials. Rx, Rp eye-hand, eye-foot testing prior to training on day 6.
Training days 11-15:	4 mode "A" and 4 mode "B" Eyespan trials. Rx, Rp eye-hand, eye-foot testing prior to training on day 11.

Subjects came in for final post-test session of Rx, Rp eye-hand and eye-foot testing within 3 days of the final training session.

The investigators and trained technicians monitored the subjects during training, performed the eye-hand/eye-foot testing and keep daily records of each subject.

Mode "B" preselected exposure time started at 1.00 second. Once the subject "hit" 80 % of the lights at 1.00 second, the exposure time was reduced to .75 second, then .50 second, etc. If a subject failed to "hit" 50% of the lights during a training session, the exposure time was increased by one level for the next training session.

80%	@	1.00 sec.	=	48 "hits"
80%	@	0.75 sec.	=	64 "hits"
80%	@	0.50 sec.	=	96 "hits"
50%	@	1.00 sec.	=	30 "hits"
50%	@	0.75 sec.	=	40 "hits"
50%	@	0.50 sec.	=	60 "hits"

No subjects did better than 80% @ 0.50 sec. Occasionally a subject did less than 50% @ 1.00 sec., so we increased the pre-set time to the next setting (1.50 sec).

RESULTS

Analyses of variance were performed on the training task (mode A), comparing the 1st, 5th, 10th, and the final training session scores. This revealed that the group demonstrated a significant improvement on the training task ($F = 8.90$, $df = 18,3$; $p < 0.0001$). A plot of the mode A training session changes shows a steady and nearly linear increase in the number of "hits" per minute throughout the training period. (Figure 6)

***** Insert Fig. 6 About Here *****

Analyses of variance were also performed comparing the 1st, 2nd, and 3rd with the pretraining Reaction Plus Rx, MR and Rp test times. The results of the individual elements tested (RH, LH, RF, LF) are explained as follows. These results are graphed using the mean test time versus the testing session number. These figures can be found at the end of the text.

The only significant change in the left hand (LH) was in MR ($F = 3.387$, $df = 18,3$; $p = .0245$). The significant differences are in LH MR1 vs. LH MR2 ($p = .0474$) and LH MR1 vs. LH MR4 ($p = .0282$) as shown by the paired t-test. The Rx ($F = 0.212$, $df = 18,3$; $p = .8874$) and Rp ($F = 2.620$, $df = 18,3$; $p = .0600$) showed no change. (Figures 7-9)

***** Insert Fig. 7, Fig. 8 and Fig. 9 About Here *****

The right hand (RH) showed significant changes in MR ($F = 3.179$, $df = 18,3$; $p = .0312$) and Rp ($F = 3.886$, $df = 18,3$; $p = .0138$). The MR change is in RH MR1 vs. RH MR4 ($p = .0295$) and the Rp changes are in RH Rp1 vs. RH Rp2 ($p = .0136$) and RH Rp1 vs. RH Rp4 ($p = .0258$) as

shown by the t-test. No change in Rx ($F = 2.216$, $df = 18,3$; $p = .0967$) was revealed. (Figures 10-12)

***** Insert Fig. 10, Fig. 11 and Fig. 12 About Here *****

The left foot (LF) showed significant changes in Rp ($F = 6.221$, $df = 18,3$; $p = .0001$) and MR ($F = 8.155$, $df = 18,3$; $p = .0010$). The Rp change is in LF Rp1 vs. LF Rp4 ($p = .0022$) and the MR change is in LF MR1 vs. LF MR4 ($P = .0008$) as shown by t-test. No change in Rx ($F = .881$, $df = 18,3$; $p = .4566$) was revealed. (Figures 13-15)

***** Insert Fig.13, Fig. 14 and Fig. 15 About Here *****

The only significant change in right foot (RF) was in MR ($F = 5.647$, $df = 18,3$; $p = .0019$). The changes are in RF MR1 vs. RF MR2 ($p = .0333$) and RF MR1 vs. RF MR4 ($p = .0027$) as shown by t-test. The Rx ($F = .949$, $df = 18,3$; $p = .4238$) and Rp ($F = 1.949$, $df = 18,3$; $p = .1327$) showed no change. (Figures 16-18)

***** Insert Fig. 16, Fig. 17 and Fig. 18 About Here *****

A paired t-test was used to compare the pre-training test times (MR1, Rx1 and Rp1) to the test times after the first 5 training sessions (MR2, Rx2 and Rp2) and to the final test times (MR4, Rx4 and Rp4). Table 2 shows the results. Any significant changes are in **bold** type.

***** Insert Table 2 About Here *****

Pearson correlation between the change in Reaction Plus pre-training to post-training times and the change in Eyespan training session 15 to training session 1 scores, were low. The r-values of these correlations are shown in Table 3.

***** Insert Table 3 About Here *****

DISCUSSION

The purpose of this study was to determine whether visual reaction and/or response speeds could be improved within a sample of elders. A program of eye-hand coordination training over a period of approximately three weeks was assessed to determine its influence on visual reaction and response speeds. The only consistent significant changes found throughout the testing process were the MR times. Each of the modalities tested (left and right hands, left and right feet) showed significant improvement from MR1 to MR4. It is impossible to determine whether these measured improvements may be attributed to the training program or to the task familiarity associated with repetitive testing. Since we found changes in MR in the eye-foot measure, which was not specifically trained, it is likely that the MR changes were due to a learning effect specific to the testing apparatus.

Significant changes were also found in the right hand and left foot Rp times. This was due only to the change in their respective MR times, not Rx times.

There were no significant changes in Rx times in any modality measured. Examination of the plots of the Rx times show some bizarre and unexplainable results. The plots of the right and left feet Rx times actually show a slowing of reaction times from Rx1 to Rx2. We examined many parameters to determine what may have caused these results, but found nothing. We can only attribute these results to subject variability.

The large amount of variability in the testing results reflects the difficulty in working with human subjects. Some of the subjects didn't keep a regular schedule of coming in for training, skipping some days which prolonged the training program beyond our initial estimate. Several subjects also reported not feeling well at times. These factors may have had some effect on the results.

Blades and Young (1986), and Velenovsky and Prasad (1987), found that Rp and MR times can be enhanced significantly among young adults through a training program using a control group to factor out the "practice effect" associated with multiple testing sessions. Although we did measure a significant improvement in all the MR and two of the Rp areas, we

did not use a control group to determine the expected "improvement" which may be attributed to repeated testing in a sample of elders. Hence, the basis for the improvements in MR found in this study is unknown.

Motivation for improvement on the testing task may have varied between subjects and caused some of the variability seen in the dependent measures. We performed our experiment primarily in the month of June, which can be a busy time for many people. The motivation of a free vision exam and the possibility of a free dinner may have not been enough to motivate the subjects to perform on a level we had hoped for. In the future there is a possibility that a minimal level of visual reaction and /or response times may be a requirement to continue to drive past a certain age. This may provide a much stronger motivational factor for improvement.

Reaction and response times have been shown to be important factors for safe driving. With the need and desire for mobility in this country and the expanding elder population, the optometric profession should be ready for, and are ideally positioned to provide the services necessary to allow the quality of life that is expected.

Although we did not achieve the results we had hoped for, the results of this preliminary study are still provocative. Other research has demonstrated that visual reaction and response times can be influenced by training. Therefore, further research should be conducted to expand and verify our preliminary results. Any such studies should incorporate the following suggestions: A more rigorous training schedule with increased compliance to schedules and stronger motivational factors. Use of a control group to compare experimental data, and fewer testing sessions so there may not be as much practice effect as we appear to have found. Also, do follow-up testing sessions at 3 and 6 months to see if there is any long lasting effects of this type of training.

REFERENCES

Blades K, Young T. The effect of training on reaction time. Unpublished doctoral thesis, Pacific University, Forest Grove, Oregon, 1986.

Brown DR. Age related changes in visual performance norms for older adults for the Pacific Sports Vision Performance Profile. Unpublished doctoral thesis, Pacific University, Forest Grove, Oregon, 1991.

Burg A. The relationship between vision test scores and driving record: General findings. (Report No. 67-24). Los Angeles: Department of Engineering, University of California, 1967.

Burg A. Vision test scores and driving record: Additional findings. (Report No. 68-27). Los Angeles: Department of Engineering, University of California, 1968.

Campbell B J. Driver age and sex related to accident time and type. Traffic Safety Research Review 1966 10, 36-44.

Coffey B, Reichow A. Optometric evaluation of the elite athlete. Problems in optometry 1990 Mar; 2(1):32-59.

Drew B, Waters J. Video games: Utilization of a novel strategy to improve perceptual motor skills and cognitive functioning in the non-institutionalized elderly. Journals of Gerontology 1990 Jan; 45(1): M25-M31.

Evans L. Older driver involvement in fatal and severe traffic crashes. Journal of Gerontology: Social Sciences 1988 43: S186-S193.

Henderson R L, Burg A. Vision and audition in driving. (Report No. NTIS PB-238-278). Washington DC: U. S. Department of Transportation, 1974.

Hills BL, Burg A. A reanalysis of California driver vision data: General findings. (Report No. LR768). Crowthorne, Berks: Department of the Environment/Department of Transport, TRRL, 1977.

Huston R, Janke M. Senior driver facts (Report CAL-DMV-RSS-86-82) Sacramento: California Department of Motor Vehicles, 1986.

Planek TW. The aging driver in today's traffic: A critical review. Aging and highway safety: The elderly in a mobile society. North Carolina Symposium on Highway Safety. Vol. 7. Chapel Hill: University of North Carolina, Safety Research Center, 1973.

Van Fraechem J, Van Fraechem R. Studies of the effect of a short training period on aged subjects. *Journal of Sports Medicine and Physical Fitness* 1977, 17, 373-380.

Velenovsky D, Prasad N. The effects of Eyespan training on eye-hand and eye-foot reaction and response time. Unpublished doctoral thesis, Pacific University, Forest Grove, Oregon, 1987.

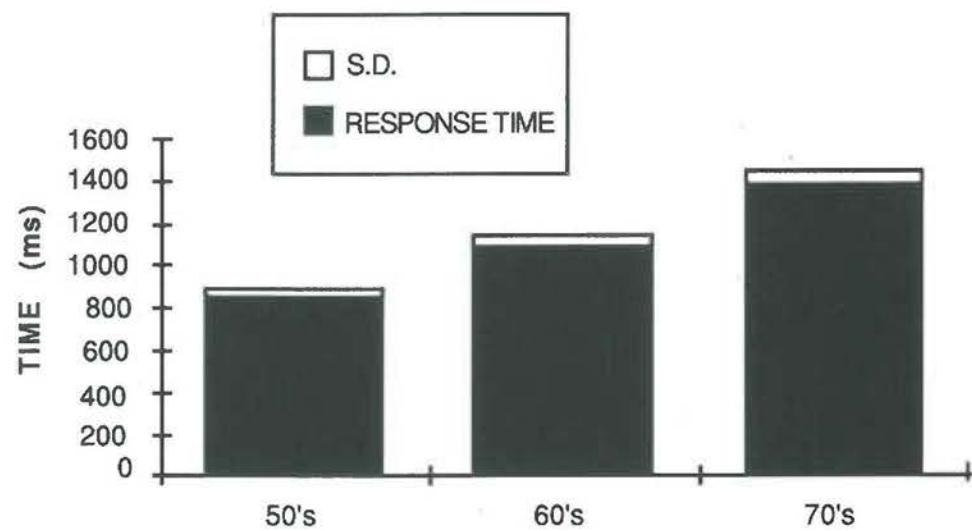


FIGURE 1. PERIPHERAL RESPONSE TIMES BY DECADE OF AGE



FIGURE 2. MONARCH AMERICA EYE-SPAN EYE-HAND COORDINATOR

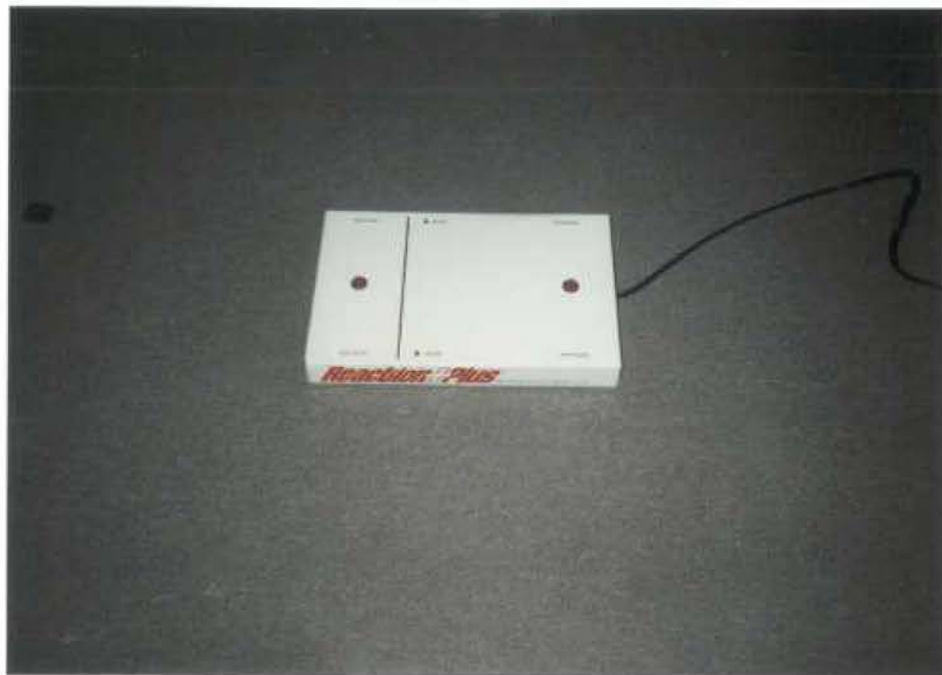


FIGURE 3. REACTION PLUS INSTRUMENT

	Post-Training Mean	Pre-Training Mean	Post-Pre	p-value
REACTION TIME *				
Control	26.8	26	0.8	p = .015
Experimental	27.9	24.7	3.2	p < .001
MOTOR RESPONSE TIME *				
Control	17.2	15.4	1.8	p = .048
Experimental	17.5	13.4	4.1	p < .001
TOTAL RESPONSE TIME *				
Control	44	41.3	2.7	p = .013
Experimental	45.4	38	7.4	p < .001

TABLE 1. COMPARISON OF YOUNG ADULT REACTION PLUS TESTING DATA. TIMES ARE IN 1/100 SEC.

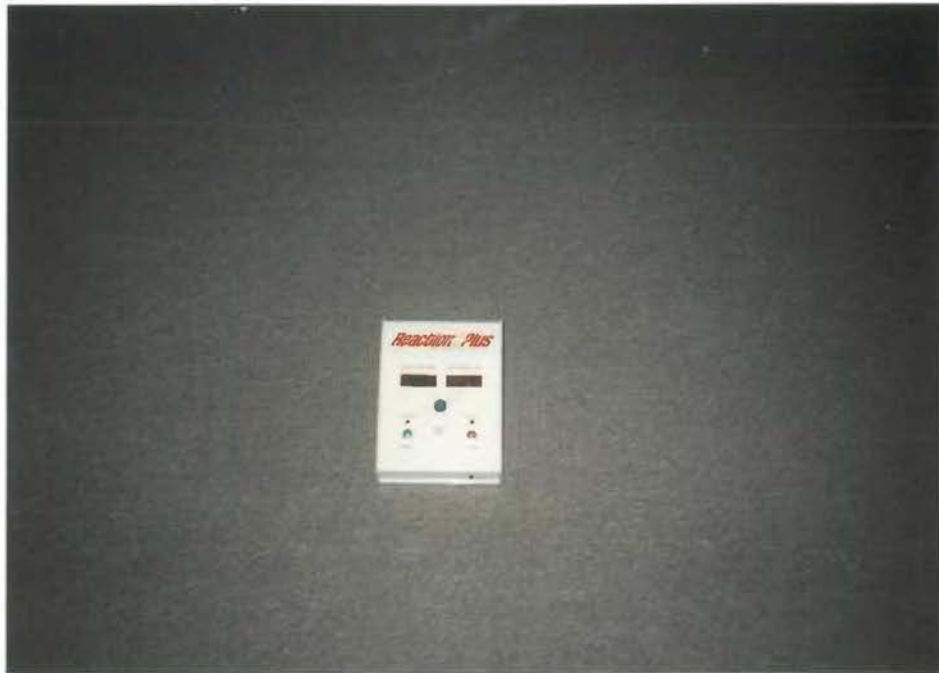


FIGURE 4. REACTION PLUS CONTROL CONSOLE.



FIGURE 5. REACTION PLUS EYE-FOOT APPARATUS.

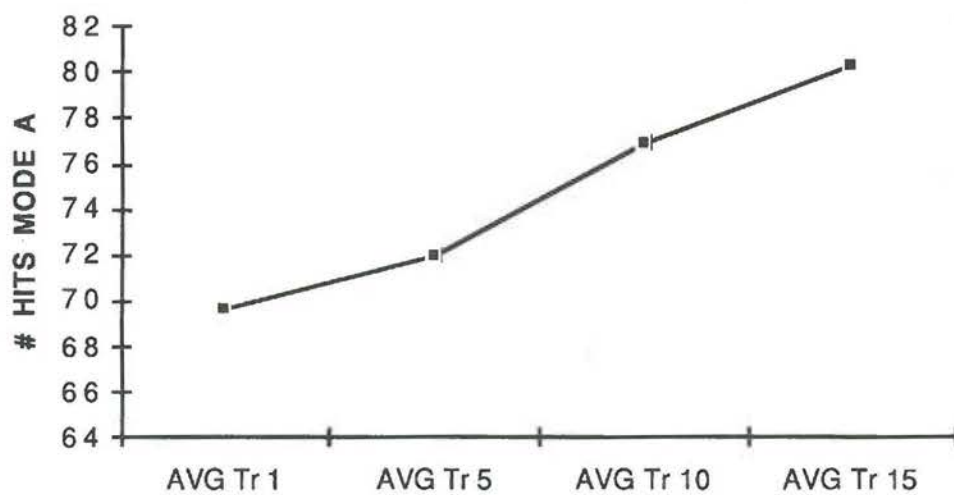


FIGURE 6. GROUP EYE-SPAN TRAINING: NUMBER OF "HITS" IN MODE A VS. TRAINING DAY.

FIGURES 7 - 10.
GROUP REACTION PLUS RESULTS OF INDIVIDUAL MODALITIES
PLOTTED AS MEAN TEST TIME VS. TESTING SESSION.
TIME: MS ERROR BARS: +/- 1 S.E.

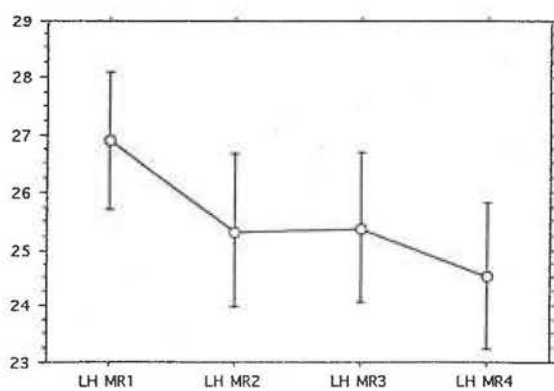


FIGURE 7.
LEFT HAND MR

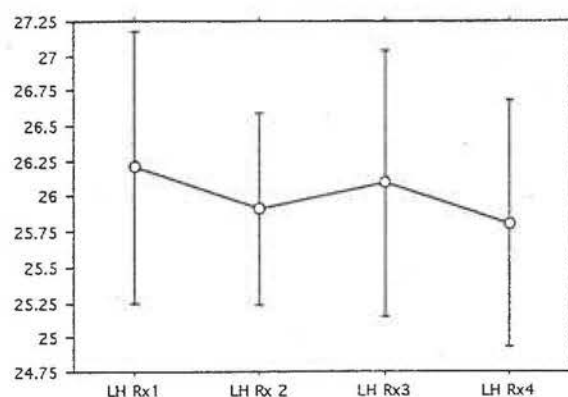


FIGURE 8.
LEFT HAND Rx

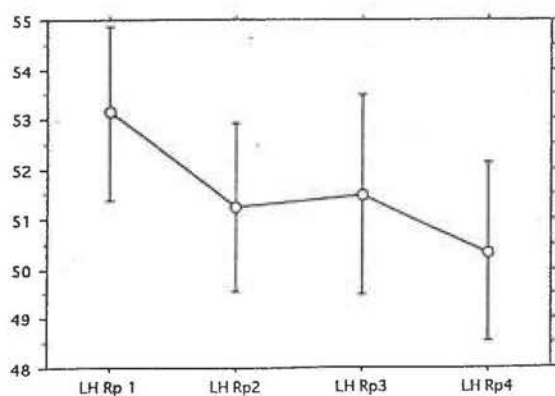


FIGURE 9.
LEFT HAND Rp

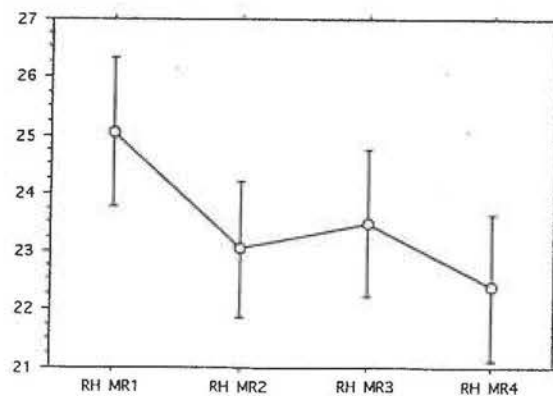


FIGURE 10.
RIGHT HAND MR

FIGURES 11 - 14.
GROUP REACTION PLUS RESULTS OF INDIVIDUAL MODALITIES
PLOTTED AS MEAN TEST TIME VS. TESTING SESSION.

TIME: MS ERROR BARS: +/- 1 S.E.

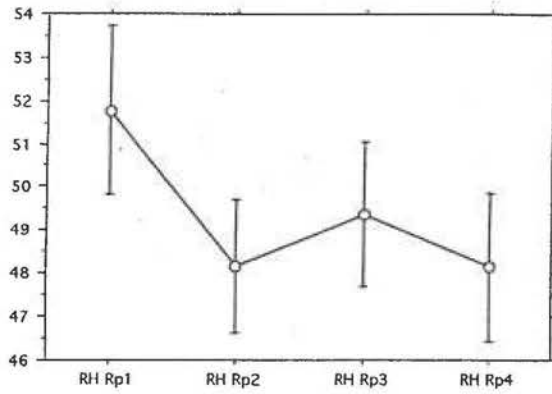


FIGURE 11.
RIGHT HAND Rp

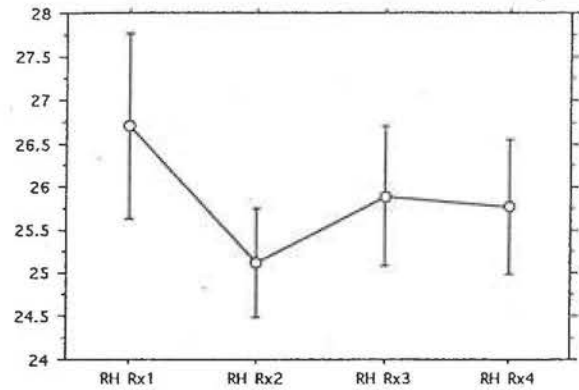


FIGURE 12.
RIGHT HAND Rx

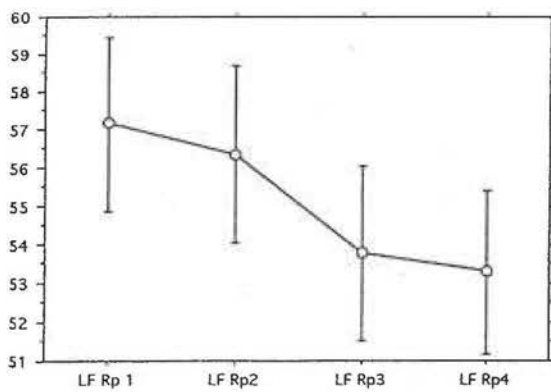


FIGURE 13.
LEFT FOOT Rp

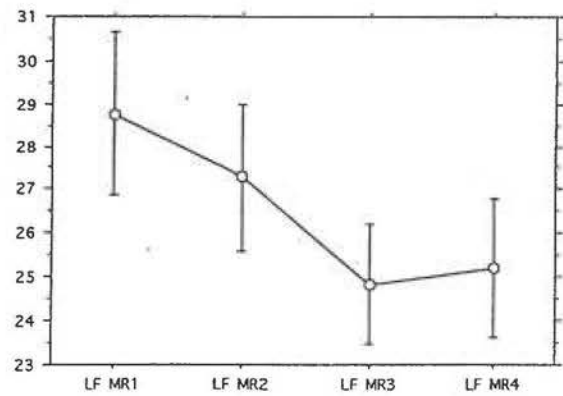


FIGURE 14.
LEFT FOOT MR

FIGURES 15 - 18
GROUP REACTION PLUS RESULTS OF INDIVIDUAL MODALITIES
PLOTTED AS MEAN TEST TIME VS. TESTING SESSION.
TIME: MS ERROR BARS: +/- 1 S.E.

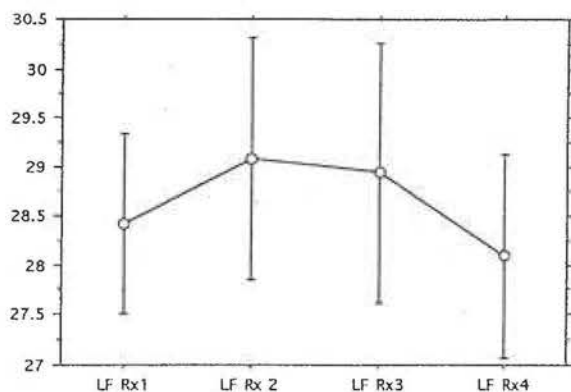


FIGURE 15.
LEFT FOOT Rx

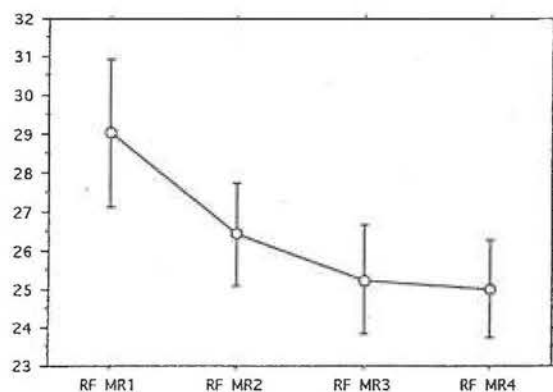


FIGURE 16.
RIGHT FOOT MR

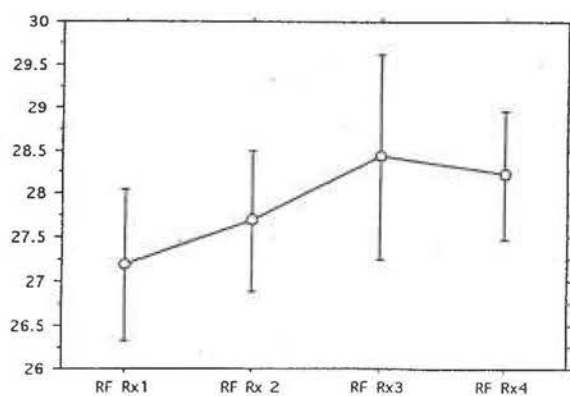


FIGURE 17.
RIGHT FOOT Rx

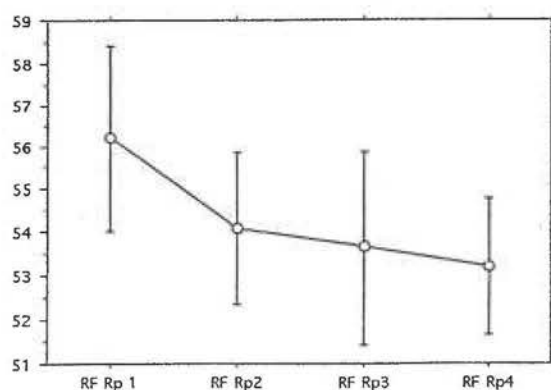


FIGURE 18.
RIGHT FOOT Rp

TABLE 2. PAIRED t - TEST FOR INDIVIDUAL MODALITIES COMPARING REACTION PLUS TESTING SESSION 1 WITH SESSION 2 AND SESSION 4. BOLD VALUES ARE SIGNIFICANT.

<u>Paired t-test</u>	<u>P-Value</u>	<u>t-Value</u>
LH Rx1, LH Rx2	.5849	0.556
LH Rx1, LH Rx4	.4602	0.755
LH MR1, LH MR2	.0474	2.128
LH MR1, LH MR4	.0280	2.390
LH Rp1, LH Rp2	.0206	2.538
LH Rp1, LH Rp4	.0255	2.435
RH Rx1, RH Rx2	.0418	2.192
RH Rx1, RH Rx4	.2007	1.328
RH MR1, RH MR2	.0537	2.065
RH MR1, RH MR4	.0295	2.364
RH Rp1, RH Rp2	.0136	2.736
RH Rp1, RH Rp4	.0258	2.430
LF Rx1, LH Rx2	.3242	-1.014
LF Rx1, LH Rx4	.6427	0.472
LF MR1, LH MR2	.1414	1.538
LF MR1, LH MR4	.0008	4.006
LF Rp1, LH Rp2	.4301	0.807
LF Rp1, LH Rp4	.0022	3.571
RF Rx1, RF Rx2	.3371	-.986
RF Rx1, RF Rx4	.2995	-1.086
RF MR1, RF MR2	.0333	2.304
RF MR1, RF MR4	.0027	3.472
RF Rp1, RF Rp2	.0620	1.990
RF Rp1, RF Rp4	.0402	2.211

Tr15-Tr1	LH RX Chng	LH MR Chng	LH Rp Chng	RH RX Chng	RH MR Chng	RH Rp Chng	LF RX Chng	LF MR Chng	LF Rp Chng	RF RX Chng	RF MR Chng	RF Rp Chng	
Tr15-Tr1	1												
LH RX Chng	0.178	1											
LH MR Chng	0.11	0.027	1										
LH Rp Chng	0.179	0.493	0.883	1									
RH RX Chng	0.056	0.831	0.186	0.552	1								
RH MR Chng	0.172	0.299	0.772	0.812	0.27	1							
RH Rp Chng	0.157	0.622	0.676	0.88	0.68	0.889	1						
LF RX Chng	-0.198	0.499	0.375	0.561	0.509	0.428	0.567	1					
LF MR Chng	0.126	0.332	0.15	0.286	0.406	0.168	0.321	-0.042	1				
LF Rp Chng	-0.016	0.575	0.351	0.575	0.642	0.398	0.608	0.573	0.795	1			
RF RX Chng	-0.051	0.406	0.208	0.372	0.435	0.439	0.541	0.514	0.179	0.459	1		
RF MR Chng	0.088	0.179	0.164	0.227	0.133	0.079	0.123	-0.072	0.633	0.475	-0.184	1	
RF Rp Chng	0.039	0.438	0.286	0.454	0.419	0.375	0.484	0.299	0.665	0.727	0.545	0.724	1

TABLE 3. PEARSON r - VALUES FOR CORRELATIONS BETWEEN SCORES IN EYE-SPAN TRAINING AND CHANGE IN REACTION PLUS TESTING SCORES.